Alaska Heat

wildland fire research & management issues

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Forest, fire, people, money:

a balancing act for managers

— by Doreen Fitzgerald

When the smoke clears and the snow falls, wildfire management usually gets little public attention, but after Alaska's severe 2004 fire season, which was more threatening than usual to human life and property, many Alaskans wanted to question and comment on wildfire issues. Some were upset about fires that were not attacked at their onset and later became hazardous to populated areas.

Although wilderness fires are a normal part of the Alaska summer, the average acres burned during 1994–2003 was 782,582. In 2004, during the state's warmest and third-driest summer on record, 696 fires burned over 6.52 million acres, according Rick DuPuis of the Alaska Department of Natural Resources (ADNR) Division of Forestry. DuPuis is the forestry division's coordinator at the Alaska Interagency Coordination Center on Fort Wainwright. The season set a state record for firefighting costs, about $106 million, but the most salient fact for the public is that many of the fires were in close proximity to Interior communities and resulted in smoke-filled days, the evacuation of several subdivisions, and disruptions for residents and tourists alike.

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"Most of us associated with wildland fire in Alaska look at 2004 as the 'once in a career' season. But since wildfires are so dramatically influenced by something as unpredictable as weather, nobody discounts the chance of another 'extreme' season in the immediate future," DuPuis said. How climate warming may affect the frequency and severity of wildland fire is a research question in Alaska and elsewhere.

Sometime between mid-July or early August, the Interior's rainy season usually marks the end of the fire season, but last summer people were still waiting for heavy rains well into September. The previous record wildfire season was in 1957, when 4.94 million acres burned. That was nearly a half-century ago. Today Alaska has nearly three times the population, and many more people live in areas known as the Wildland Urban Interface, where lives and property can be threatened by fire. DuPuis said that three of the 2004 fires were declared emergency incidents by the Federal Emergency Management Agency (FEMA). "The only other FEMA declarations [for fire] in Alaska were for the Tok River fire in 1990 and the Millers Reach fire in 1996."

In Alaska initial fire management decisions are based on the "Alaska Interagency Wildland Fire Management Plan," which provides guidelines for initial attack based on the risk to human values, such as life and property. "Fire managers have discretion to deviate from the plans, but usually will not do so without concurrence from the land manager," said DuPuis.

Managers must balance the need to protect human values against the cost and risk of fighting a fire, and sometimes the higher priority need for firefighting resources elsewhere in the state. Sometimes firefighters try to suppress new fires as quickly as possible; other times, a fire is fought only to prevent it from encroaching on structures or communities, rather that with the goal of extinguishing it. Whatever the scenario, when wildfire occurs fire managers have to consider the values at risk for damage, current conditions such as weather, and their finite resources.

What is not possible from a cost perspective, and not desirable from a forest ecology perspective, is the suppression of all wildland fire. In fact, the forest is a little like a bonfire that builds itself—the longer it goes without fire, the greater its fuel load, and the more likely it is to ignite, either through human error or a natural cause, such as a lightning strike. In the long run, suppressing all fire can result in more intense burns (amount of heat released) or more severe burns (how deep it consumes soil duff), unless the continuity of fuels is broken up through thinning and other measures. This is of course not practical in immense stretches of forested wildland.

In November the Alaska Wildland Fire Coordinating Group held a series of community meetings to review the 2004 fire season, discuss the wildfire management plan, and take public comment, which was also accepted by mail. Meetings in the Interior, where most of the 2004 fires occurred, were held at Two Rivers, Central, Circle, Fairbanks, Venetie, Fort Yukon, Delta Junction, Eagle, Dot Lake, Tanacross, Northway, Chatanika/Poker Flats, and Tok; a meeting also was held in Anchorage. At these sessions managers briefed the public on the wildland fire management plan and its annual review process. A summary of comments and responses will be made available to the public, and is expected to be finished this spring.

Students in professor Susan Todd's natural resource management classes served as recorders at three Fairbanks area meetings. Their participation was arranged by Chris Maisch, who is the northern regional forester for the Alaska Department of Natural Resources (ADNR), Division of Forestry and a member of the advisory board for the School of Natural Resources and Agricultural Sciences (SNRAS).

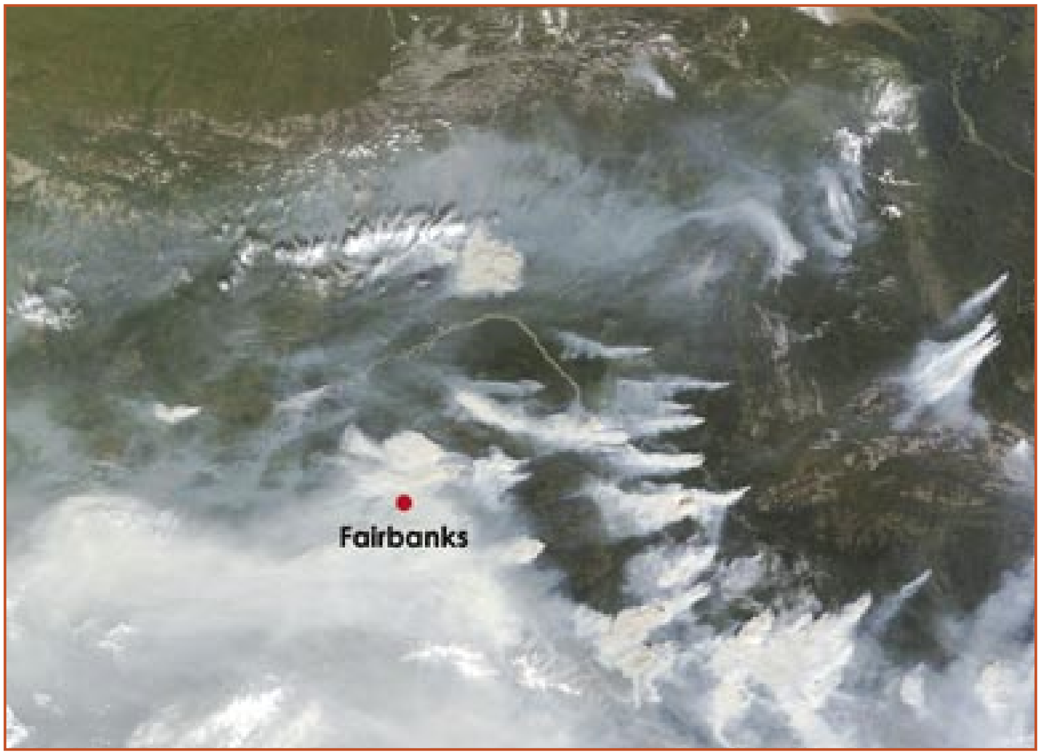
The Alaska Wildland Fire Coordinating Group is responsible for statewide fire planning and coordinates Alaska's fire management effort. Because wildland fires occur on state, federal, and private land, it is composed of representatives from federal and state agencies, and Alaska Native organizations. Representing the state are the ADNR, and the departments of Fish and Game (ADFG), and Environmental Conservation (ADEC); the federal agencies are the Fish and Wildlife Service (USFWS), Bureau of Land Management (USBLM), National Park Service (USNPS), Forest Service (USFS), and Bureau of Indian Affairs (USBIA). Various Alaska Native organizations are also represented.

For management purposes, Alaska was split into thirteen different geographic areas and a separate "Area Specific Alaska Interagency Wildfire Management Plan" was developed for each. In 1998 the coordinating group completed a long-term project to amend these into one plan, making it possible to understand the state's wildland fire operations without having to refer to thirteen documents. The amended plan provides one guide for management options, responsibilities, and operations, making it easier for fire suppression organizations to deploy their limited resources during active fire seasons. The amendment contains the common elements of the area-specific plans, but does not change their intent, the option selections for managers, or any fire protection option boundaries. It does not change the landowner or land manager's responsibilities and their ability to determine how fire will be managed on their lands.

The wildland fire plan establishes four options for determining initial attack priorities and responses. The goals are to provide, using available resources, the appropriate level of protection for human life, private property, and identified resources; to ensure that fire suppression costs are commensurate with values identified for protection; and to optimize the ability of landowner managers to achieve their individual management objectives. When fire occurs, the agencies jointly responsible for providing fire suppression services are the Alaska Fire Service (sponsored by USBLM), the ADNR Division of Forestry, and USFS. Although the plan options are followed whenever possible, they remain a plan; during extreme fire seasons, all fires may not be fought at their designated level due to lack of manpower or funding.

The **Critical Management** option is the highest priority for suppression action on wildland fires and pertains to areas where fire threatens human life, inhabited property, designated physical developments, and to structural resources designated as National Historic Landmarks. Fires occurring in or that immediately threaten areas with this designation are given the "highest priority for protection from wildland fires by immediate and continuing aggressive actions dependent on the availability of suppression resources."

The **Full Management** option is meant to protect cultural and historic sites, uninhabited private property, natural resource high-value areas, and other high-value areas that do not involve the protection of human life and inhabited property. Fires



Smoke from 2004 wildfires in interior Alaska is shown in this 250-meter natural color composite of MODIS data received at the University of Alaska Fairbanks by the Geographic Information Network of Alaska. The dense smoke plumes and thick haze caused an increase in the incidence of respiratory problems for many Interior residents, hampered summer tourism, and dramatically reduced summertime visibility.
— Published courtesy of the Geographic Information Network of Alaska: **www.gina.alaska.edu**

Wildland fire in the Innoko National Wildlife Refuge. Photo by Laura Reid, courtesy of the U.S. Fish and Wildlife Service.

occurring within this designation or that immediately threaten it "receive aggressive initial attack depending on the availability of suppression resources."

The most flexible option, **Modified Management**, is intended to provide a higher level of protection when fire danger or risks are high, and a lower level of protection when fire danger or risks are low. fires within this category are evaluated on a conversion date, generally July 15, at which point, if managers concur, they would convert to limited suppression status. The intent is not to minimize acres burned, but to balance acres burned with suppression costs and to accomplish land and resource management objectives. Depending on fire danger or risk, fires in these areas may receive initial attack or periodic surveillance. Lands under Modified receive initial attack early in the fire season, but are treated as Limited (see next section) after a conversion date, typically in mid-July, when changes toward cooler, wetter weather reduce risk of developing large fires.

The **Limited Management** option is for areas where the cost of suppression may exceed the value of the resources to be protected, where fire suppression activities may have more negative effects than the fire itself, or where the exclusion of fire may be detrimental to the fire-dependent ecosystem. Fires in these areas receive periodic surveillance. Also, within the confines of land-manager policy, individual sites may receive protection. If necessary, additional suppression actions may be taken to keep a fire within the boundary of the area under this management option or to protect identified higher-value areas or sites.

State, federal, and other landowners determine the options for various sites on their lands. A digital file of the Alaska Interagency Wildland Management Plan is available at http://www.dnr.state.ak.us/forestry/pdfs/98AIFMP.pdf. A map of Alaska lands fire supression status is available at http://www.myfirecommunity.net/documetns/Appendix_B.pdf.

How wildland fire behaves

Three of the most important factors affecting fire ignition and behavior are fuel load, weather, and topography. "Obviously!" you might say, if you've ever tried to light a campfire using large pieces of wet fuel in a clearing at the top of a hill on a rainy day. But what exactly does this mean in terms of a fire's behavior?

Fuel Load. What kind and how much fuel surrounds a fire affects its spread. The fuel load (number and size of fuel pieces per area) depends on the forest's age, succession stage and species, and how much time has passed since the area's last burn. Human activities can affect the fuel load as grass replaces trees or homes are built. Small fuel loads result in low intensity fires that spread slowly. Higher fuel loads result in more intense fires that spread faster or have a longer residence time on a site, thus burning more severely. Dry fuels create fires that are harder to contain. Flashy fuels (dry grass, pine needles, dry leaves, or twigs and other dead brush) burn faster than large logs or stumps. Ease of ignition is related to the relationship of fuel surface to volume. A tree has high volume relative to its surface area; twigs ignite more easily because they have a low volume relative to their surface area (thus can dry more rapidly after rain). The spacing of fuels is also a factor. Fuels spaced slightly apart will dry out more easily and receive more oxygen; packed fuels retain more moisture, and are harder for a fire to dry. The creation of a fuel break with little or no fuel can significantly slow a fire, and combined with suppression activities, can stop one.

In an wildland-urban interface like parts of the Tanana Valley, the fire plan calls for aggressive initial attack of wildfire starts, because of the potential threat to human life and property. To counter the buildup of fuel loads in such areas, prescribed burns and various forestry practices can be used to gain the beneficial effects of wildfire: reducing fuel loads or fuel continuity and enhancing wildlife habitat. However, resources to apply these treatments are limited. On the other hand, fires may be allowed to burn on land with a limited-suppression status. When these areas are relatively close to populated ones, the possibility exists that under certain conditions a fire may become a problem fire, threatening people, which was the case with the 2004 Boundary Fire. The problems created by that fire were well reported, but there is another side of the story: from a fuels management perspective, it was a good fire, because it removed a large amount of very hazardous fuel from the interface.

Also related to fuels is vegetation type. The thesis research of SNRAS MS graduate Justin Epting, "How do vegetation types and topography affect burn severity?" has confirmed at a landscape scale the general hypothesis that a broadleaf shrub or broadleaf forest stand can act as an effective fire break, whereas black spruce stands typically have higher burn severity values. Elevation also influenced burn severity, presumably due to its control on vegetation composition. David Verbyla, professor of geographic information systems, was his major professor. Epting used remote sensing methods to investigate the study questions. Areas vegetated with spruce forest had higher burn severity than broadleaf forests and unforested areas. Higher density spruce, with its greater fuel load, had the highest burn severity values.

Weather. Moisture in the form of precipitation and humidity reduces the probability of wildfire, slows fire growth, reduces its intensity, and may extinguish it. Moisture absorbs the heat in potential fuels, so they're harder to ignite when their moisture level is high. Fires are less likely to start or grow when the humidity is high, which keeps fuels from drying out. Low rainfall creates favorable conditions for wildfires. Temperature directly affects wildfire ignition because heat, along with oxygen and fuel, are what it requires. Radiant heat from the sun heats and dries potential fuels: trees, brush, and vegetation debris. After ignition, warmer temperatures will cause a fire to burn and spread faster. During the wildland fire season, you will notice that wildfires tend to rage in the afternoon, when temperatures are highest. Researchers project that if Alaska's current climate warming trend continues, more and/or larger wildland fires are likely.

After ignition, wind affects fire behavior the most, and it is the least predictable and most problematic factor. It can cause the fire to spread faster and grow larger, and can make firefighting more difficult. Wind increases the oxygen supply to the fire and can further dry out potential fuels. A fire also generates its own wind, which can be more intense than the wind surrounding the fire. Fire spotting occurs when wind throws embers ahead of the primary fire and ignites more fires, significantly increasing the rate of spread. Wind can change a fire's direction, and crown fires occur when wind gusts raise the fire into the treetops.

A prescribed burn near Beaver Villate. Photo courtesy of the U.S. Fish and Wildlife Service.

Topography. The stable factor in wildland fires is topography, which can promote or retard a fire's progression; slope is the most important land feature. Usually fire travels much faster uphill than downhill, and faster up steeper slopes. The ambient wind usually flows uphill, and because the fire preheats the fuel upslope from it as the heat and smoke rise in that direction, the fire also moves upward. On a hilltop, the fire can't preheat the downhill fuel as well, so traveling downhill is more difficult, and a fire may burn out once it reaches the top of the slope.

Benefits of fire

The forest fire prevention and Smokey Bear campaign that began over 60 years ago has in some ways been too successful, promoting the idea that all wildland fire is bad. While human-error fires are not viewed as desirable, there is increasing acceptance of the positive role of fire in forest health and the idea that managing fires, rather than total suppression, is an important tool. Although last summer's largest fires were caused by lightning, humans ignite the majority of wildland fires in Alaska. In 2003, only 18 of the 357 fires on state-protected lands were sparked by lightning; the rest were ignited by people. On state lands, 80 percent of fires are human caused.

Not all fires burn everything as they move across the land, and how fire affects vegetation varies considerably depending on vegetation type and other factors. Because of this, wildland fire often creates a mosaic pattern, as it thoroughly burns some areas (high severity) and hardly touches others. This creates natural breaks in the vegetation (fuel), and this discontinuous fuel will prevent or slow the spread of future wildfires. It also diversifies habitat, which results in wildlife diversity.

Wildfire can benefit plant growth by reducing disease spread, releasing nutrients from burned plants into the ground, removing the insulating duff layer over permafrost, and exposing mineral soil to encourage new growth. Because of the way wildfires move across the landscape, they often don't burn deeply enough into the soil to kill roots of existing plants; lush new vegetation often sprouts soon after a fire, which benefits many animals.

The boreal forest has evolved and adapted to a cycle of burn, regeneration, and species succession. In the Interior, depending on location, this cycle varies from about 90 to 150 years on average. Fire, the major disturbance in the forest, maintains diverse vegetation and wildlife populations, both of which contribute to the ecosystem's overall productivity. Typically, fire creates a forest that has a mosaic pattern of single-aged stands of trees. Without fire, forest succession would result in atypical all-aged stands.

Black spruce *(Picea mariana)* forests are relatively susceptible to fire. With thin bark and shallow roots, the tree is easily killed by fire. Immediately following fire, large quantities of seeds commonly are released because the cones store some seeds until heat causes them to open fully. White spruce *(Picea glauca)* is also easily killed by fire, but it does not store seeds in its cones for more than a year. It relies on wind-dispersed seed from nearby surviving trees to colonize burned sites. For more on white spruce regeneration, see page 8. Hardwoods such as birch *(Betula neoalaskana)* or aspen *(Populus tremuloides)* can colonize a burned site by seed or sprouting.

In 2004, four of the largest wildland fires were caused by lightning strikes and cost more than $62 million to control: the 119,500-acre Solstice Complex fire (6/24–7/21); the 614,974-acre Eagle Complex fire (6/29–7/24); the 537,098-acre Boundary Fire (6/13–9/2); and the 451,152-acre Central Complex fire (7/13–9/3). DuPuis said that at the peak of the 2004 firefighting efforts, there were 2,711 people in the field, and Alaska had support coming from 46 states, two Canadian provinces and two U.S. territories. A great many of them had to be supplied off-road, which added to the expense.

The boreal forest of North America covers 1.4 billion acres. Natural resource managers who deal with wildland fire in Alaska's boreal forest have to assess and act on how it can best be managed for human values while providing the forest with the natural burns with which it has evolved. People living in the Wildland Urban Interface areas, or in any rural development, can contribute to their own wellbeing by creating a defensible space around homes and villages before wildland fire threatens.

For More Information

U.S. BLM Alaska Fire Service
http://fire.ak.blm.gov/

U.S. Fish and Wildlife Service, Alaska Region
http://alaska.fws.gov/

National Interagency Fire Center
http://www.nifc.gov/

USDA Forest Service
http://alaska.fws.gov/fire/

Frostfire experimental wildfire website
http://www.fs.fed.us/pnw/fera/frostfire/

"Western Forests, Fire Risk, & Climate Change"
http://www.fs.fed.us/pnw/pubs/science-update-6.pdf

Climate & fire, Canadian research
http://fire.cfs.nrcan.gc.ca/research/climate_change/factsheets/factsheet1_e.htm

UAF research on human-fire interactions in the Alaska and Yukon Territory regional system:
http://www.hfi.uaf.edu/

For information about fire ecology or the ADFG habitat enhancement program, contact Dale Haggstrom (dale_haggstrom@fishgame.state.ak.us) or Thomas Paragi (tom_paragi@fishgame.state.ak.us).

Watching the trees return

Natural regeneration of the boreal forest after fire literally has made the forests that are managed today in Alaska. In the SNRAS forest sciences department, a long-term study monitoring the actual individual performance of a large population of white spruce seedlings is giving new insight into the mechanisms that govern this process of forest renewal. The Rosie Creek Fire Research Project began in 1983 following a 8,600-acre wildfire in the Bonanza Creek Experimental Forest, now also the Bonanza Creek Long Term Ecological Research (LTER) site. It is currently led by forest ecology professor Glenn Juday. From 1989 through 2003, research technician Robert Solomon was responsible for measurements and the study database. Along with the white spruce study, work has been done comparing regeneration of paper birch, aspen, and spruce in burned stands. Research installations in the fire area are permanently marked and available for monitoring and integration into the expanded range of studies underway in the LTER site.

Since 1988, all white spruce seedlings in the 2.47-acre plot have been mapped and the annual survival and height growth measured. All seedlings belong to the 1983, 1987, or 1990 seed crops. The study will yield the first predictive equations of white spruce height growth as it relates to climate, seed-crop year following fire, and other factors. These numbers may be useful in setting natural reforestation standards, in calibrating models of forest growth, and in predicting forest growth under different climate scenarios. The data provides the probability that trees will reach height benchmarks in a given year and shows the very great advantage of immediate seed crops following forest disturbance. The study identifies the factors that promote and hinder white spruce establishment and early growth.

This is the longest continuing and most detailed look at the exact amount of tree regeneration and what conditions are associated with tree success in boreal Alaska. The Reserve West hectare plot used in the study is typical of highly productive upland forest sites, and the trends reported here should have wide applicability to sites managed for the production of wood products. The diary of the regeneration of the white spruce in the research plot is summarized below, along with some information on the burned stands of aspen, paper birch, and white spruce.

1988 Although all trees were killed in the fire and these dead trees have been standing for five years, no snagfall has occurred in the burned birch stand. The burned aspen stand has experienced only a minor amount of snagfall, but has a dense understory of four-meter tall aspen suckers. The suckers have been grazed to the snowline at least once by moose.

1989 An intensive effort resulted in location and mapping of 305 white spruce seedlings, all of which belong to two age classes, 1983 seed crop and 1987 seed crop. The project has been incorporated into the LTER database and monitoring program.

Natural regeneration mapping and measurements also have been completed on three burned hectares for aspen, white spruce, and paper birch. All seedling trees have been mapped and measured on the burned paper birch and white spruce hectares and on a subsample of two plots in the burned aspen stand. The burned white spruce stand was poorly stocked with seedling white spruce, totaling only 305 in the hectare. White spruce seedlings were patchily distributed; 35% of the study cells had no white spruce seedlings, 15% had only one, and 11% had two. On the other hand, 7% of the cells had ten or more white spruce seedlings, mainly along the northern edge of the hectare that lies within the critical 200-meter effective dispersal radius of surviving mature white spruce trees that serve as propagule sources.

In contrast, aspen reproduced about ten times more vigorously (3,000 stems in the hectare) than white spruce. Although aspen was a minor component of the stand before the fire, 56 percent of the cells had aspen stems, which in most cells were wind-borne seedlings. In portions of the stand that supported aspen before the fire, aspen sprouting was especially vigorous. Thirteen percent of the cells had 50 or more aspen, and four cells had 400 or more aspen stems. The burned birch hectare supported nearly equal numbers of aspen and paper birch stems at a low density (1,126 and 1,087 respectively), probably because of high fire severity in that portion of the burn. Paper birch stems were distributed more evenly than aspen; 74% of the cells supported paper birch; 71% had no aspen or only one; 6% of the cells had 50 or more aspen stems but no cell had 50 or more paper birch stems. Stem densities in the burned aspen stand were especially high; six cells (48% of the total cells in the subsample) were stocked with 600 or more aspen stems, a projected rate of 60,000 per hectare.

Snagfall was monitored in all burned stands. Six years after the fire, the only material that has fallen to the ground in the burned paper birch and white spruce stands has been treetops, limbs, and a very few snags. By contrast, snagfall was very dynamic in the burned aspen stand, where there was a 197 aspen snag and log population in 1988, and 48 new snagfalls this year. This year 66 white spruce trees fell; large primary falling trees, especially white spruce, often knocked down other trees. Most snagfall was associated with the gradual enlargement of one major and two minor canopy gaps, probably because of the ragged edge the gaps presented to the wind.

1990 To date, 581 white spruce seedlings have been mapped. Work focused on locating and mapping; the additional seedlings all belong to the 1987 seed crop and their growth made them significantly more visible during the year. They face severe competition from grass and forbs, but the 1983 seed crop seedlings have reached heights of 50 centimeters or more and will soon overtop the competing vegetation. The major challenge to the near-term survival of the established spruce seedlings is snagfall. The large dead trees from the stand that burned in 1983 will begin to fall soon and may cover or affect five to ten percent of the reference stand surface area.

The top photo was taken seven growing seasons after the fire, in October 1989. Nearly all fire-killed snags are still standing and the forest floor is a dense mat of bluejoint grass, fireweed, and horsetail. White spruce regeneration is sparse and the white spruce seedlings are too small to locate. The same site is shown in May, 1993 in the second photo. During 1992-1993, about half of the standing snags from 1983 fell to the forest floor, many during a period of high winds in May 1993.

1991 There are now 921 seedlings, which appear to be all the remaining ones.

1992 Natural regeneration of white spruce depends on the conjunction of different chance events (fire, seedbed conditions, timing of seed crops).

1993 Work focused on relocating and mapping white spruce seedlings in the reference stand, which belong to two age classes, 1983 and 1987 seed crops. The 1991 survey did not account for all seedlings; this year the count increased by 46%, apparently because

In October 2002, nineteen growing seasons following the fire, individual broadleaf tree stems have begun to dominate. The 1983 and 1987 seed crop white spruce seedlings have emerged above the height of fallen logs, and the 1990 seed crop seedlings have become visible.

By October 2003, the white spruce have greatly expanded following exceptionally favorable (cool and moist) summer weather. There is a large green needle mass in the white spruce from abundant moisture. Birch and aspen trees have added significant diameter growth.

1987 seed crop seedlings grew enough during 1992 to finally become significantly more visible. Only 7 out of 100 cells in the reference plot had no seedlings, compared to 13 cells in 1990. Only 18 out of 921 seedlings measured in 1991 have died, suggesting that the seedling density is below the level at which intra-specific competition is a significant mortality factor, at least for these early years of stand development. During 1992-1993, about half of the standing snags from 1983 fell to the forest floor, many during a period of high winds in May 1993. Several of the larger seedlings were crushed by falling snags.

1995 Mapped and measured spruce seedlings now number 1,678, including 1,459 alive and 219 that have died during the study. There are 148 new seedlings and only 16 seedling deaths during the previous year. Seedlings have germinated from 1983, 1987, and 1991 seed crops. White spruce regeneration surveys are not likely to be accurate before the fifth year; nearly all in this study have been discovered in the third through fifth years following the seed crop. The greatest risk to spruce seedlings (5.8% of all seedlings encountered) is from falling snags of the mature trees killed in the 1983 fire. About 300 (20 percent) of the seedlings alive in 1995 have lost their terminal buds or leaders, primarily due to animal (moose and snowshoe hare) browsing, but also due to mechanical damage from falling dead trees. The average height growth of 1983 seed-crop seedlings in 1994 (measured in 1995) was 11.9 centimeters, which is equal to or below 1991–1993 height growth. This reduced growth correlates with high drought-stress levels.

1999 In the database now are 2,389 spruce, including 2,126 alive in October 1999 and 262 that died since monitoring began. Most 1983 seed crop white spruce now have excellent position and many will become new canopy trees. Only some 1987 seedlings are positioned well enough to emerge into the canopy. Hardly any 1990 seed crop seedlings will emerge until the death of overtopping vegetation, which may take a century. The spring survey measured height elongation of all spruce and a fall survey measured 1999 height growth. Spruce seedlings nearly all originated from the 1983, 1987, or 1990 seed crop. Mean spruce height growth was 6.1 cm and mean total height was 48.9 cm in 1998; corresponding figures were 8.6 cm annual growth and 55.8 cm total height in 1999. The best-performing seedlings are the 1983 seed crop, with 1998 mean height growth of 15.4 cm and 18.7 cm during 1999 for total heights of 122.6 cm and 138.6 cm in 1998 and 1999 respectively. Height growth was significantly below predictions from the 1997 trend line, probably because of drought in 1997 and 1998. Data from this stand are being used in large spatially explicit computer models of forest regeneration. This year all hardwoods (aspen and paper birch) with stem diameter greater than two centimeters were mapped and measured in one-fourth of the plot.

2000 There are now 2,402 white spruce seedlings in the database, including 2,120 currently alive and 282 that have died. Apparently, at the low-to-moderate density of stems in the monitored portion of the stand, mortality of seedlings over the twelve-year monitoring period has been low (11.7%). In 2000, the mean height growth of all white spruce seedlings was 12.5 cm, a 146.7% increase over 1999 and the highest measured in the series. Only 17.4% (368) of seedlings alive now are from the 1983 seed crop; their mean height growth in 2000 was 24.8 cm, a 133.5% increase over 1999, for a mean total height of 161.7 cm. The 1983 seed crop seedlings are the best positioned for eventual dominance of the site, and are in transition between the ground-layer of vegetation and an emerging forest canopy. The acceleration in height growth in 2000 is correlated with significantly cooler summer temperatures in 1999 and 2000 than in the previous 25 years, and the occurrence of relatively abundant and well-timed rain in the summers of 1999 and 2000.

2001 Mean 2001 growth of 1983 seed crop seedlings was nearly identical to growth in the 2000 season, which was the greatest of all years measured. Continued cool, and relatively moist summer climate appears to be responsible for the excellent growth. A re-evaluation of the assignments to age classes was completed.

2002 The germination year in the database for all seedlings was reviewed and corrected. Mean 2002 growth of 1983 seed crop seedlings was the greatest yet (26 cm) reflecting the third year of optimum cool and moist summer weather. Average height of 1983 seedlings was 192 cm (76 in) and 71% of 1983 seedlings were greater than breast height (137 cm or 4.5 ft), a height that serves as a benchmark for likely future success in becoming part of the dominant tree canopy. Average height of 1987 seedlings was 66.5 cm (26 in), and 6% were taller than breast height, the first significant numbers to reach that height.

2003 All seedlings were mapped and measured at the end of the growing season (year 15), and growth of a subsample was measured weekly. Mean height growth of 1983 seed crop seedlings (19.4 cm) was less than the previous year for the first time since 1998. Hot, dry weather stopped height growth by early to mid June. Despite the wettest July in the last century, height growth did not resume. For the 1983 seed crop, 84% of seedlings were taller than 100 cm and mean total height was 207 cm. For 1987 seeds, 34% were taller than 100 cm and mean total height was 84 cm. For the 1990 crop, 5% were taller than 100 cm and mean total height was 42 cm. Seedlings taller than 100 cm in the early years of regeneration have overtopped shrubs and herbs and have good potential to become part of the canopy if they are not overtopped in turn by hardwood trees. The best-positioned 1983 seedlings accomplished about 40% of their total height in the three climatically favorable cool and moist years of 2000-2002, demonstrating that there is not a typical seedling height growth following fire, but highly variable growth depending on the weather that is actually experienced.

2004 Seedlings were measured in October 2004; the information is being incorporated into the database.

— Doreen Fitzgerald with Glenn Juday
Photos by Glenn Juday

Modeling fuels and fire to improve management

Smoke from the 2004 Boundary Fire, courtesy Alaska Fire Service, Bureau of Land Management

Forestry professor Scott Rupp and others are developing computer models to improve the information available to those who must plan for wildfire on the millions of burnable acres in Alaska and elsewhere.

Fire-mediated changes in the Arctic System: Interactions of changing climate and human activities

As human populations progressively expand into wildland areas, fire management issues are increasingly important. The same natural fire regimes (fire frequency, intensity, and size) that underlie the structure and function of many wildland areas also threaten human life and property. An understanding of the processes that control fuel accumulation, including the role of socioeconomic activities, is crucial for designing sound, effective management policies.

The National Science Foundation (NSF) has awarded Rupp and several other principal investigators a $1.35 million grant for interdisciplinary research that will examine, from a regional system perspective, the limits to resilience as directional changes are induced by biophysical and social drivers. The project will document and model how fire affects the Arctic climate system and its human residents, and particularly how human activities affect the fire regime. F. Stuart Chapin III, IAB professor of biology and wildlife, is the lead principal investigator for the work. Rupp received his PhD from UAF in 1998.

The research team will quantify how sensitive the region's boreal forest is to human perturbations of the natural fire regime and will identify how human activities affect the short- and long-term frequency and extent of fire. The proposed modeling approach aims to develop plausible scenarios of future changes in Alaska's fire regime and the consequences to society. This whole-system model will serve as an integrative and adaptive planning tool. It will provide an overarching research framework and will be a synthesis tool for applying understanding of the system to management and decision analysis issues.

The project will modify and test the ALFRESCO model so that it has the capability to consider human effects on the fire regime. The investigators will use these models to assess climate feedbacks associated with plausible scenarios of future climate and fire regime that the project will develop. The study will build on the research of Rupp and A. David McGuire of the UAF Institute of Arctic Biology (IAB): "Modeling the role of high latitude terrestrial ecosystems in the Arctic System: a retrospective analysis of Alaska as a regional system."(NSF OPP-0095024). Seed money to develop the successful proposal was provided in 2003 by the UAF EPSCoR Program (Experimental Program to Stimulate Competitive Research), a joint program of NSF and several U.S. states and territories. For more on this research, visit the website Human-Fire Interactions, http://www.hfi.uaf.edu/.

Cooperating with Rupp, Chapin, and McGuire on the new project are Amy Lovecraft, UAF professor of political science and northern studies, David Natcher of St. John's College, Newfoundland (formerly of the UAA anthropology department), and IAB postdoctoral student Sarah Trainor. (NSF 0096-0328282).

A computer model for management of fuels, human-fire interactions, and wildland fires in Alaska's boreal forest

Interior Alaska contains 140 million burnable acres and the largest national parks and wildlife refuges in the country. On average, wildland fires annually burn one million acres in the Interior and threaten the lives, property, and timber resources of Alaska's sparse but growing population. Although wildland fires threaten human values, they also are crucial for the maintenance of forest ecosystems. This work aims to provide information for wildland fire management that is mutually beneficial for both humans and natural ecosystems.

This model will integrate fuel buildup, vegetation, climate, and fire-management policy with real geography over time scales of years, decades, and centuries. It will produce mapped depictions of changes in wildland fuels, fire risk, and vegetation under multiple future scenarios of fire management, climate change, and human development. It will serve as an integrative and adaptive planning tool for land managers designing fire-management plans that can safeguard both human and natural values.

Recently this model was used to investigate how changing fire frequencies might affect the winter habitat of caribou, specifically the Nelchina caribou herd in eastern interior Alaska. This work incorporates results from a previous study, "evaluating influences of varied wildland fire regimes on caribou forage lichen abundance through state and transition models." Because caribou wintering in boreal forest ecosystems forage primarily on climax-stage fruticose lichens, and wildland fire can reduce their availability for decades, factors affecting fire regime on winter range could influence the animals' nutritional and population status. This preliminary research involved developing a spatially explicit succession model to evaluate specific objectives relative to influences of various fire and climatic regimes on abundance and distribution of caribou forage lichens. A paper on this work has been submitted to the journal Ecological Applications.

Currently working on the management computer model with Rupp are SNRAS graduate students Tom Kurkowski (MS candidate) and Paul Duffy (PhD candidate). Duffy's first thesis chapter was accepted for publication by Ecological Applications (in press). Other participating researchers are Daniel Mann, IAB research associate; Randi Jandt of the Alaska Fire Service (U.S. Bureau of Land Management); Karen Murphy of the U.S. Fish and Wildlife Service; Layne Adams of the Alaska Biological Science Center (U.S. Geological Survey); and Bruce Dale of the Alaska Department of Fish and Game. The project was highlighted by the Joint Fire Science Council in their 2003 annual summary to Congress. It is funded through 2005 by the federal Joint Fire Science Program.

Fuel load analysis work. Photo by Scott Rupp.

Modeling fire risk to improve management decisions

Rupp has been working with Robert Haight of the U.S. Forest Service and Rich Howard of Assisi Software Corporation to assess the vulnerability of human populations to wildfire in the lake states of Minnesota, Wisconsin, and Michigan, where wildfire risk is high. This region has large numbers of fire ignitions and areas of fire-prone forest types. Past fire suppression and forest management has led to uncharacteristically expansive tracts of fire-susceptible ecosystems with altered age-class distributions of short-lived species (e.g., jack pine and balsam fir), changes that have produced serious forest health concerns, including insect infestations and natural senescence, resulting in increased fuel loadings and their attendant fire risk.

This research aimed to develop new approaches to regional fire risk assessment that couple ecological and social factors into a fire risk and consequence model, with an emphasis on reducing the potential for loss of life and property. The overall goal is to provide managers with a scientifically based decision-support tool for prioritizing fire risk reduction activities in a regional, landscape, and local context. The study was reported in the *Journal of Forestry*, Vol. 2, No. 7, October–November 2004.

An analysis of community vulnerability to wildfire will produce spatial data sets of current vulnerability based on biophysical-based fire risk, human settlement patterns, and suppression resources. Spatial data sets of community vulnerability to wildfire will provide critical current fire risk information to fire management personnel, as well as long-term information to both fire managers and planners. This project was extended in 2003. A spatial model has been developed for evaluating fuel treatment plans using genetic algorithms (a technique developed for spatial optimization) as a novel optimization strategy. Another peer-reviewed journal article will be submitted in February. This work was funded by the U.S. Forest Service.

Fuel load analysis and fire risk assessment for the Municipality of Anchorage

Research has demonstrated that fuel management practices will reduce fire behavior or severity. The goal of this research is to model the expected fire behavior in the Anchorage wildland-urban interface and to identify fuel inputs that can be proactively managed so as to minimize Anchorage's risk and exposure to any such fire. This research should immediately benefit Anchorage fire managers, who can use the results for that purpose. Extreme fire behavior can be reduced by selective thinning and other fuel-reduction actions.

Rupp, David Valentine, and Dan Cheyette of SNRAS and Sue Rodman of the Anchorage Fire Department cooperated on this project to inventory the fuels present in Anchorage's wildland-urban interface, create custom fuel models that accurately describe the fuels inventoried, model the expected fire behavior were a wildfire to occur in the wildland-urban interface under current forest conditions, and identify fuel conditions that should, according to our model, lessen either or both of the predicted fires extent and intensity.

MS student Dan Cheyette completed custom fuel models for the Anchorage Fire Department and Alaska Division of Forestry for the 2004 fire season. Cheyette graduated in July 2004. This project was funded by grant funds from the Anchorage Fire Department.

— *Compiled by Doreen Fitzgerald*

An area of boreal forest burned over during the Long Creek Fire. Photo courtesy of professor Scott Rupp.

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